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Article in *Journal of the European Economic Association* · December 2010

DOI: 10.1111/j.1542-4774.2010.tb00553.x · Source: RePEc

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DOES INFLATION TARGETING ANCHOR LONG-RUN INFLATION EXPECTATIONS? EVIDENCE FROM THE U.S., UK, AND SWEDEN

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Abstract

We investigate the extent to which inflation expectations have been more firmly anchored in the United Kingdom—a country with an explicit inflation target—than in the United States—a country with no such target—using the difference between far-ahead forward rates on nominal and inflation-indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons. We show that far-ahead forward inflation compensation in the U.S. exhibits substantial volatility, especially at low frequencies, and displays a highly significant degree of sensitivity to economic news. Similar patterns are evident in the UK prior to 1997, when the Bank of England was not independent, but have been strikingly absent since the Bank of England gained independence in 1997. Our findings are further supported by comparisons of dispersion in longer-run inflation expectations of professional forecasters and by evidence from Sweden, another inflation-targeting country with a relatively long history of inflation-indexed bonds. Our results support the view that an explicit and credible inflation target helps to anchor the private sector's views regarding the distribution of long-run inflation outcomes. (JEL: E31, E52, E58)

The editor in charge of this paper was Jordi Gali.

Acknowledgments: In compiling the data for this project, we received invaluable help from Jan Alsterlind, Andrew Clare, Lars Hörngren, Michael Joyce, Peter Lildholt, and Lena Stromberg. The paper has also benefited greatly from discussions, comments, and suggestions from Paul Beaudry, Alan Blinder, Mick Devereux, Ken Kuttner, Rick Mishkin, Scott Roger, Brian Sack, Klaus Schmidt-Hebbel, Eric Parrado, Lars Svensson, Jonathan Wright, and seminar participants at the Swedish Riksbank, the International Monetary Fund, Johns Hopkins University, UC Berkeley, the European Central Bank, Università Bocconi/IGIER, Bilkent University, the European University Institute, the Federal Reserve Board, European Summer Symposium in Macroeconomics, and the NBER Monetary Economics Program Meeting. We appreciate the excellent research assistance of Andrew Marder, Claire Hausman, and Oliver Levine. The views expressed in this paper are solely those of the authors, and do not necessarily reflect the views of the Board of Governors of the Federal Reserve System, the management of the Federal Reserve Bank of San Francisco, or any other person associated with the Federal Reserve System.

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1. Introduction

Long-term price stability is a central goal of monetary policy for virtually every modern central bank.¹ To facilitate the achievement of this objective, a number of national and supranational central banks have adopted an “inflation targeting” framework, in which a numerical objective for inflation is explicitly stated, vigorously pursued, and clearly communicated to the public in the form of periodic, detailed reports on the current and projected outlook for inflation and other aspects of the macroeconomy (cf. Bernanke et al. 1999).² The adoption of inflation targeting has been encouraged by a growing body of literature regarding the advantages of this framework in the formulation and communication of monetary policy (e.g., Persson and Tabellini 1993; Walsh 1995).³

Nevertheless, empirical analysis using quarterly realizations of inflation or survey-based measures of inflation expectations has so far yielded at best weak support for the notion that inflation targeting (IT) significantly influences the behavior of inflation. In particular, quarterly inflation rates and short-term inflation forecasts have not behaved very differently in IT and non-IT economies, because all of the major industrial nations experienced significant disinflation in the early-to-mid 1990s (Ball and Sheridan 2005; Gertler 2005).⁴ Moreover, analysis of longer-term inflation expectations has been hampered by a scarcity of data due to the relatively recent adoption of IT in most countries and the low (typically semiannual) frequency of surveys that measure long-run inflation expectations (Levin, Natalucci, and Piger 2003).

In this paper, we evaluate the influence of inflation targeting on long-term inflation expectations by comparing the behavior of daily bond yield data in the United States and the United Kingdom. Both countries have highly liquid markets for nominal and inflation-indexed government bonds across a wide range of maturities, which allows for the computation and comparison of forward nominal and real interest rates in each country.⁵ *Forward inflation compensation*—defined

1. In other periods, of course, one can find many instances in which a central bank's primary objective was to provide the government with cheap credit and seigniorage revenue.

2. See also Leiderman and Svensson (1995), Bernanke and Mishkin (1997), and Kuttner (2005).

3. See also Svensson (1997), McCallum (1996), Bernanke et al. (1999), and Svensson and Woodford (2003).

4. See also Bernanke et al. (1999) and Johnson (2002).

5. In ongoing research, we are working to extend the methods of this paper to other inflation-targeting countries. However, the data limitations for other countries are often severe or prohibitive: for example, New Zealand has only one inflation-indexed bond outstanding, which makes the computation of forward rates impossible. Canada had only one inflation-indexed bond until 1996 and only two from 1996 to 2001, and even these bonds have extremely long durations (30 years) and low liquidity, making implied forward rates difficult to estimate and noisy. High-frequency data on market forecasts of macroeconomic statistical releases in Australia, New Zealand, and Finland are not available, to our knowledge. Finally, data in developing countries with inflation targets, such as South Africa and Chile, tends to be even more limited.

as the difference between the forward rates on nominal and inflation-indexed bonds—measures the compensation that investors demand to cover the expected rate of inflation and the risks associated with that inflation at a given horizon.⁶

In contrast to previous empirical studies of inflation targeting, the daily frequency of our bond yield data, together with the frequent release of important macroeconomic statistics and monetary policy announcements, enables us to obtain relatively precise estimates of the impact of these news releases on far-ahead forward inflation compensation, even for samples spanning only half a decade or so. If far-ahead forward inflation compensation is relatively stable and insensitive to incoming economic news, then that would suggest that financial market participants have fairly stable views regarding the distribution of long-term inflation outcomes, and hence that the monetary policy framework has been reasonably successful in anchoring long-term inflation expectations.

Our analysis reveals substantial differences between the U.S. and UK with respect to both the unconditional and conditional behavior of far-ahead forward inflation compensation. For the United States, we find that far-ahead forward inflation compensation is quite volatile, especially at lower frequencies, and exhibits highly significant responses to economic announcements. Furthermore, the magnitude of these responses does not diminish after a day or two, as one might have expected if economic news were merely inducing transitory fluctuations in market liquidity. Interestingly, we find very similar results for the UK prior to 1997, when the Bank of England was not independent, but not for the period since mid 1997, when the Bank of England was independent. In particular, for the post-1997 sample of UK data, we find that far-ahead forward inflation compensation exhibits very little volatility, especially at low frequencies, and does not respond significantly to economic news. These results support the view that a transparent and credible inflation target helps to anchor the private sector's perceptions of the distribution of long-run inflation outcomes.

Importantly, our analysis of inflation compensation implicit in long-term bond yields does not rely on the expectations theory of the term structure; that is, these patterns need not be due solely to shifts in the conditional mean of the inflation rate at long horizons.⁷ In particular, if inflation expectations are not completely anchored, then economic news might well shift the far-ahead forward *inflation risk premium*, either because near-term economic developments affect investors' perceptions regarding the distribution of long-run inflation outcomes, or because the economic news has a significant impact on the price that investors attach

6. In contrast to yields, the use of forward rates avoids any direct influence from short-term developments, thereby permitting a sharper focus on inflation expectations at a particular horizon. See Section 2.

7. For empirical evidence regarding the failure of the expectations hypothesis, see Fama and Bliss (1987), Campbell and Shiller (1991), and Cochrane and Piazzesi (2005).

to those long-run inflation risks. In contrast, if inflation expectations are firmly anchored, with a time invariant distribution around the specified target value, then economic news should have a much smaller impact on far-ahead forward inflation compensation.

Our conclusions about the impact of inflation targeting are also bolstered by some additional sources of evidence. First, we consider surveys of professional forecasters and document the extent to which dispersion in long-run inflation expectations is markedly higher for the United States than for the United Kingdom. Second, we analyze daily bond yield data from Sweden, another inflation-targeting country with a history of inflation-indexed government securities spanning a range of maturities, albeit traded in markets that are notably less liquid than those of the United Kingdom or the United States. Our results using the Swedish data match those of the post-1997 UK data, namely, Swedish economic news does not have any significant influence on far-ahead forward inflation compensation, consistent with the view that long-run inflation expectations in Sweden are firmly anchored. Moreover, these results further undermine the notion that the U.S. findings might be due to fluctuations in market liquidity rather than to movements in expected inflation and perceived inflation risk at long horizons.

The remainder of the paper proceeds as follows. Section 2 describes our daily data and how we compute forward nominal and real interest rates, inflation compensation, and the surprise components of macroeconomic data releases and monetary policy announcements. Section 3 compares the unconditional volatilities of far-ahead forward inflation compensation in the United States and the United Kingdom. Section 4 evaluates the extent to which U.S. far-ahead forward inflation compensation is sensitive to economic news, and Section 5 performs this analysis using UK data over the pre-independence and post-independence sample periods. Section 6 presents additional evidence from U.S. and UK surveys of professional forecasters and from Swedish bond yield data. Section 7 concludes. An Appendix at the end of the paper provides further details regarding all of the data series.

2. Methods and Data

If the steady-state inflation rate is constant over time and known by all agents—that is, if inflation expectations are well-anchored—then standard macroeconomic models predict that inflation should return to its steady state well within 10 years after a shock (Gürkaynak, Sack, and Swanson 2005; Gürkaynak, Levin, and Swanson 2006). To test whether this prediction is met in the data, we must look beyond the effects of economic announcements on the first few years of the term structure and focus instead on the response of far-ahead *forward* interest rates and inflation compensation to the announcement.

2.1. Forward Interest Rates and Forward Inflation Compensation

Forward rates are often a very useful means of interpreting the term structure of interest rates. For a bond with a maturity of m years, the yield $r_t^{(m)}$ represents the rate of return that an investor requires to lend money today in return for a single payment m years in the future (for the case of a zero-coupon bond). By comparison, the k -year-ahead one-year forward rate $f_t^{(k)}$ represents the rate of return from period $t+k$ to period $t+k+1$ that the same investor would require to commit at time t to a one-year loan beginning at time $t+k$ and maturing at time $t+k+1$. The linkage between these concepts is simple: An m -year zero-coupon security can be viewed as a sequence of one-year forward agreements over the next m years. The k -year-ahead one-year forward rate $f_t^{(k)}$ can thus be obtained from the yield curve by the simple definition:⁸

$$1 + f_t^{(k)} = \frac{(1 + r_t^{(k+1)})^{k+1}}{(1 + r_t^{(k)})^k}. \quad (1)$$

For the U.S., we use data on nominal and real forward rates on U.S. Treasury securities produced by the Federal Reserve Board going back to 1998.⁹ For the UK, we use data on nominal and real forward rates on UK government securities produced by the Bank of England going back to 1985.¹⁰ For Sweden, we computed nominal and real forward rates from data on nominal and inflation-indexed Swedish government yields obtained from the Swedish Riksbank going back

8. If we observed zero-coupon yields directly, computing forward rates would be as simple as this. In practice, however, most government bonds make regular coupon payments and thus the size and timing of the coupons must be accounted for to translate observed yields into the implied zero-coupon yield curve. In Gürkaynak, Levin, and Swanson (2006), we also reported results using U.S. Treasury STRIPS data, which are actually traded zero-coupon securities, and showed that our results are not sensitive to using actually traded as opposed to implied zero-coupon yields. Note also that our yield curve data for the U.S., UK, and Sweden are all quoted on a continuously compounded basis, which implies that our forward rate data is given by $f_t^{(k)} = (k+1)r_t^{(k+1)} - kr_t^{(k)}$ rather than equation (1), which is for annually compounded yields.

9. The Federal Reserve Board computes daily implied zero-coupon yields from off-the-run U.S. Treasury yields using the extension of the Nelson–Siegel (1987) method proposed by Svensson (1994); see Gürkaynak, Sack, and Wright (2005) for details. U.S. inflation-indexed bonds (TIPS) were issued for the first time in January 1997 and only annually in the first few years after that date, so our far-ahead forward real rate data for the U.S. begins in January 1998. Although the Federal Reserve Board provides a full estimated real yield curve only back to January 1999 (Gürkaynak, Sack, and Wright, 2010), we extend the 9–10 year forward rate series back to January 1998 by taking the 9- and 10-year TIPS rates and computing the implied forward rate between the two using the Shiller–Campbell–Schoenholtz (1983) approximation.

10. The Bank of England computes implied zero-coupon nominal and real yields from observed UK government yields using a spline-based procedure (details and data are available from the Bank of England's Web site), with daily data available back to 1985.

to 1996.¹¹ Although the yield curves of different countries are estimated using somewhat different methodologies, this has no effect on our results as all of these are very well-fitting yield curves that reveal the underlying discount functions appropriately. Having obtained forward nominal rates and forward real rates for each country, we define forward *inflation compensation* to be the forward nominal rate less the forward real rate at each horizon. Note that this measure captures the compensation that investors demand both for expected inflation and for the risks or uncertainty associated with that inflation at that horizon.

Given our interest in measuring long-term expectations, we focus our analysis on the longest maturity for which we have high-quality data for both real and nominal bond yields. The exceptional liquidity, depth, and breadth of the markets for government securities near the 10-year horizon thus suggests focusing on the one-year forward rate from 9 to 10 years ahead (i.e., the one-year forward rate ending in 10 years). This horizon is sufficiently far out for standard macroeconomic models to return essentially to steady state, so that any movements in forward inflation compensation at these horizons are very difficult to attribute to transitory responses of the economy to a shock.

2.2. Regression Specification

We compare the unconditional volatility of far-ahead forward inflation compensation in the U.S. and UK and also the sensitivity of forward inflation compensation in each country to major macroeconomic announcements. To study the sensitivity of inflation compensation, we run a series of high-frequency event-study regressions of the form

$$\Delta y_t = \alpha + \beta X_t + \varepsilon_t, \quad (2)$$

where t indexes days, Δy_t is the change in forward inflation compensation over the day, X_t is the surprise component of the macroeconomic data releases and monetary policy announcements that took place that day, and ε_t is a residual representing the influence of other factors on y_t that day. As a benchmark for comparison, we also run regressions of the form (2) with the change in the one-year spot nominal interest rate on the left-hand side.

We now describe in detail the data that underlie this analysis.

11. For Sweden, we backed out the implied zero-coupon yield curves and forward rates using the Svensson (1994) methodology (which was designed for Swedish data and is the same method employed by the Federal Reserve Board for U.S. data) and checked that these did in fact fit the Swedish bond data very well. The first inflation-indexed Swedish government bond was issued in March 1994, but additional indexed bonds were not issued until May 1996, when a range of four new maturities were issued, so our forward real rate data for Sweden begin in May 1996.

2.3. *Macroeconomic Data Releases*

Financial markets are forward-looking, so the expected component of macroeconomic data releases should have essentially no effect on interest rates.¹² To measure the effects of macroeconomic data releases on interest rates, then, we must first compute the unexpected, or surprise, component of each release. Using the surprise component of the releases also removes any issues of endogeneity arising from interest rates feeding back to the macroeconomy, because any such effects, to the extent that they are predictable, will be incorporated into market expectations for the release.

To measure the surprise component of each data release in our sample, we compute the difference between the actual release and the median forecast of that release made by professional forecasters just a few days prior to the event. For the U.S. and UK, we obtained data on professional forecasts of the next week's statistical releases for around fifty macroeconomic time series for each country collected and published every Friday by Money Market Services (MMS).¹³ However, not all of these statistics have a significant impact on interest rates, even at the short end of the yield curve. Thus, to conserve space and reduce the number of exogenous variables in our regressions, we restrict attention to only those macroeconomic variables that have the largest and most statistically significant effects on the spot one-year Treasury bill rate in those countries.¹⁴ Note that this selection procedure does not bias our estimates of the sensitivity of far-ahead forward interest rates to economic news because those interest rates are insensitive to all macroeconomic and monetary policy announcements under the null hypothesis. Our results herein are very similar when we include all available variables on the right-hand side of the regression.

In contrast to the U.S. and UK, data on professional forecasts is more limited for Sweden. Thus, for that country we use all of the available professional forecast data collected by Bloomberg Financial Services every week.¹⁵

12. Kuttner (2001) tests and confirms this hypothesis for the case of monetary policy announcements.

13. The quality of the MMS data as measures of expectations has been verified by previous authors—see, for example, Balduzzi, Elton, and Green (2001) and Andersen et al. (2003).

14. In particular, for the U.S. we begin with all releases and choose those that have a statistically significant effect on the 1-year nominal rate. Core CPI is added to this list because this variable is highly significant in longer samples and belongs in a study of inflation expectations *a priori*. New home sales, another important release, did not make it into the final list. Its inclusion would have made our results even stronger. For the UK and Sweden the variable lists are determined by availability and our desire to span releases about prices, real activity and monetary policy.

15. Bloomberg offers forecasts of a greater number of Swedish statistics than Money Market Services and were more readily available to us. For the U.S. and UK, the Bloomberg forecast data do not go back as far as the MMS data (about 1996 for Bloomberg vs. 1985 for MMS-U.S. and 1993 for MMS-UK), but the two data sources agree very closely when they overlap.

Additional details regarding the macroeconomic data releases and professional forecast data for all of these countries are included in the Data Appendix at the end of this paper.

2.4. Monetary Policy Announcements

As with macroeconomic data releases, we must compute the surprise component of monetary policy announcements in each country in order to measure the effects of these announcements on interest rates. Rather than use the median of professional forecasts to measure expectations, however, we use the one-day change in a short-term interest rate, such as a 3-month government bill rate, around each monetary policy announcement to measure the surprise component of the announcement. The advantage of using market-based measures of monetary policy surprises is that they are of higher quality and are available essentially continuously—see, for example, Krueger and Kuttner (1996), Rudebusch (1998), and Gürkaynak, Sack, and Swanson (2007).

For the U.S., we measure monetary policy surprises using the change in the current-month federal funds future contract on the dates of Federal Reserve monetary policy announcements, as in Kuttner (2001). For the UK and Sweden, we do not have futures data for the policy rates of the corresponding central banks, so we measure monetary policy surprises using the change in the spot 3-month UK government bill rate on the days of Bank of England monetary policy announcements and the change in the 3-month Swedish government bill rate on the days of Riksbank monetary policy announcements. The change in the 3-month rate on these days reflects changes in financial market expectations about the current and future course of monetary policy over the subsequent 3 months—although this is not the same as the shorter horizon one would obtain from a very near-term futures contract, it is nonetheless an excellent measure of the change in the near-term monetary policy environment.¹⁶ Additional details regarding these announcements and financial market measures of the surprise component of these announcements are provided in the Data Appendix.

3. The Unconditional Volatility of Forward Inflation Compensation

3.1. The United Kingdom

Figure 1 illustrates the use of far-ahead forward inflation compensation to assess the anchoring of long-term inflation expectations in the UK. In Figure 1, we plot

16. We have verified that using the 1-day change in the 3-month U.S. Treasury bill rate to measure the surprise component of U.S. monetary policy announcements does not alter our findings. We stick with federal funds futures as the preferred measure for the U.S. because that is the most common in the literature and because Gürkaynak, Sack, and Swanson (2007) showed that, among the many possible financial market instruments that potentially measure U.S. monetary policy expectations, federal funds futures are the most accurate in a forecasting sense.

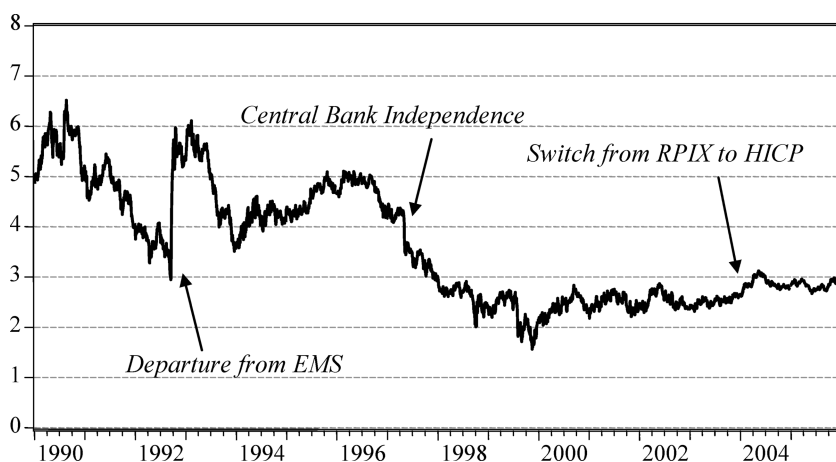


FIGURE 1. The evolution of far-ahead forward inflation compensation in the United Kingdom, 1990–2005. The figure depicts the daily series of the nine-year-ahead one-year forward rate of inflation compensation for the United Kingdom over the period 2 January 1990 through 28 December 2005.

the daily time series of 1-year forward UK inflation compensation 9 years ahead (that is, the forward nominal interest rate from 9 to 10 years ahead less the forward real rate from 9 to 10 years ahead). There are three particularly noteworthy events in the figure. First, in September 1992, this measure of inflation compensation soared about 250 basis points over the course of a week, as the British government dropped out of the European Monetary System and adopted a floating exchange rate regime. Interestingly, the following month's announcement of the adoption of a 2.5% inflation target did not generate any noticeable decline in forward inflation compensation, presumably reflecting the extent to which the announced inflation target was not viewed by financial markets as being particularly credible (a theme to which we will return subsequently).

Second, in early May 1997, Chancellor of the Exchequer Gordon Brown made a surprise announcement that the Bank of England would be granted operational independence from the Exchequer and Parliament.¹⁷ Far-ahead forward inflation compensation plummeted by an amazing 75 basis points that day, and then declined further during the remainder of the year as the new policy regime became institutionalized and the Bank of England released its first Inflation Report. From early 1998 through the end of our sample in 2005, far-ahead forward inflation

17. The 6 May 1997 announcement came as a surprise to financial markets, particularly the scope of the announcement: According to the BBC, the "surprise announcement . . . is being described as the most radical shake-up in the Bank's 300-year history" (British Broadcasting Corporation 1997). Central bank independence was officially passed into law on 23 April 1998 with an effective date of 1 June 1998.

compensation remained in the range of about 2% to 3%, apparently reflecting the confidence of financial markets the Bank of England would indeed keep inflation close to the prescribed target.

Finally, in early December 2003, the Chancellor of the Exchequer announced that the inflation target would be specified in terms of the consumer price index (CPI) instead of the retail price index excluding mortgage interest (RPIX), and that the numerical target for CPI inflation would be set at 2%, a half percentage point lower than the previous target for RPIX inflation.¹⁸ However, as Bank of England Governor Mervyn King (2004) noted in a subsequent speech, this methodological change effectively raised the inflation target by a bit less than half a percentage point, because RPIX inflation had typically exceeded CPI inflation by nearly a full percentage point over the previous decade. As evident from Figure 1, far-ahead forward inflation compensation rose by about 40 basis points in the wake of the adjustment to the inflation targeting regime and remained at this somewhat higher plateau throughout 2004 and 2005.

3.2. *The United States*

Figure 2 compares the behavior of far-ahead forward inflation compensation for the United States with that of the United Kingdom.¹⁹ The differences between the two series are striking, especially since the beginning of the current decade. First, the U.S. series has an average value close to 3%, more than 30 basis points higher than the average for the UK series. Second, the U.S. series has exhibited much greater volatility, with an unconditional standard deviation of about 0.4%, roughly twice as high as the unconditional volatility of the UK series. Finally, the fluctuations in U.S. far-ahead forward inflation compensation are much more persistent than in the UK data.

Figure 3 compares the spectrum of far-forward inflation compensation for the United States with that of the United Kingdom.²⁰ Spectral analysis provides a convenient way of visualizing the persistence of each series, because the unconditional variance is given by the integral of the spectrum, and the height of the spectrum at each frequency shows the extent to which stochastic fluctuations at that frequency contribute to the overall variance. As is evident in the figure,

18. The CPI, or Harmonized Index of Consumer Prices (HICP), was regarded as a better measure of inflation than the core Retail Price Index (RPI), which included some interest financing costs, among other things. Moreover, the HICP was the standard measure of inflation being adopted by members of the European Monetary Union. Inflation indexed government securities in the UK are indexed to the RPI.

19. Starting in January 2004, the UK series incorporates a constant 40-basis-point adjustment that reflects the switch from RPIX to CPI in the definition of the inflation target.

20. The spectrum is computed using autoregressive spectral density estimation (cf. Priestley 1981).

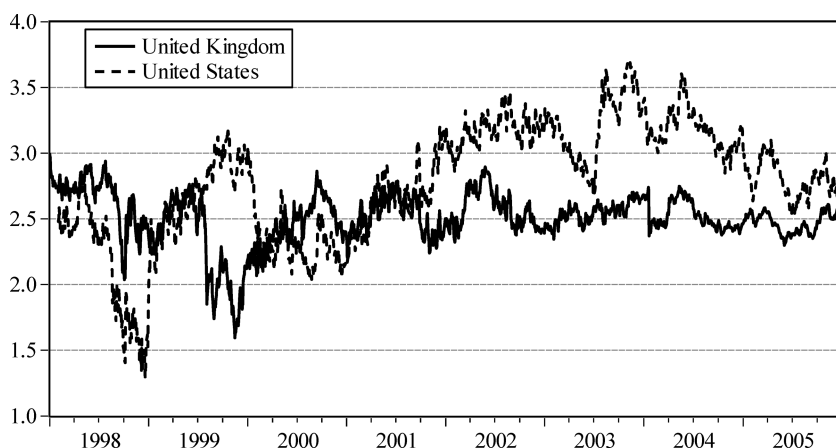


FIGURE 2. Comparing the evolution of far-ahead forward inflation compensation in the United Kingdom vs. the United States, 1998–2005. This figure depicts the daily series of 9-year-ahead 1-year forward rates of inflation compensation for the United States (dashed line) and the United Kingdom (solid line) over the period 2 January 1998 through 29 December 2005. Starting in January 2004, the UK series incorporates a constant 40-basis-point adjustment that reflects the switch from RPIX to HICP in the definition of the inflation target.

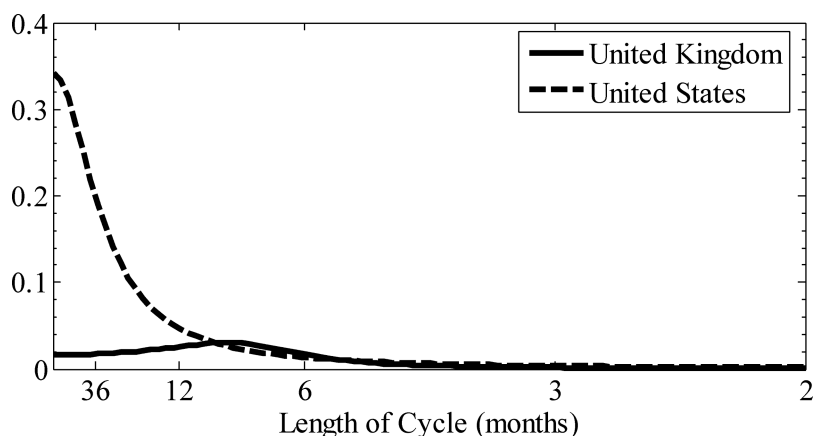


FIGURE 3. The spectral decomposition of far-ahead forward inflation compensation in the United Kingdom vs. the United States, 1998–2005. This figure depicts the spectral density function of the 9-year-ahead 1-year forward rate of inflation compensation for the United States (dashed line) and for the United Kingdom (solid line), using monthly average data for 1998:01 through 2005:12. Starting in January 2004, the UK series incorporates a constant 40 basis point adjustment that reflects the switch from RPIX to HICP in the definition of the inflation target. For each series, the spectral density is shown over frequencies from 0 to $\pi/2$, corresponding to cycles lasting 2 months or longer.

U.S. and UK forward inflation compensation exhibit roughly similar magnitudes of high-frequency, transitory variation of the sort that might be associated with fluctuations in market liquidity or other technical factors.

In contrast, the *persistent* component of the volatility of the U.S. data is dramatically higher than that of the UK data, fully accounting for the difference between the unconditional variances of the two series. These unconditional moments of the data foreshadow the key results that we obtain below, namely, that the greater volatility of U.S. far-ahead forward inflation compensation seems to arise from systematic and persistent movements in investors' inflation expectations (and perceived inflation risk at long horizons) and not from transitory technical factors or market noise.

4. The Sensitivity of U.S. Inflation Compensation to Economic News

Although far-ahead forward inflation compensation in the U.S. has been more volatile than in the UK, especially with respect to the persistent component of the two series, it is natural to ask whether and to what extent this difference has been systematic. That is, does U.S. inflation compensation appear to fluctuate randomly, perhaps because of liquidity or other technical factors, or does U.S. inflation compensation appear to respond systematically to major macroeconomic news? A systematic difference in responsiveness would suggest that the higher volatility of U.S. inflation compensation is not due to liquidity or other technical bond market behavior, but is instead related to varying bond market expectations or concerns regarding the distribution of long-run inflation outcomes.

Table 1 reports the results for regression (2) applied to far-ahead forward inflation compensation and also to the spot one-year nominal interest rates as a benchmark for comparison. Each of the two columns reports the results from a regression of daily changes in the short-term interest rate (or far-ahead forward inflation compensation) on the surprise component of the major economic announcements listed at the left. We restrict attention in the regressions to only those days on which some macroeconomic statistic was released or a monetary policy announcement was made, but our results are not sensitive to this restriction. Note that, although there are nearly 800 daily observations in each of these regressions on which some major economic announcement was made, most of those observations for any individual regressor are zero because any given macroeconomic statistic is only released once per month (or once per quarter in the case of GDP, once per week in the case of Initial Claims).

To aid in interpreting our coefficient estimates, each macroeconomic surprise is normalized by its standard deviation, so that the coefficients in the table report the interest rate response in basis points per standard deviation surprise in the corresponding macroeconomic statistic—the one exception to this rule is for

TABLE 1. U.S. forward rate responses to economic news (1998–2005).

	1-year Nominal Rate	1-year Forward Inflation Compensation ending in 10 yrs
Core Consumer Price Index	1.23 (1.74)	1.51* (2.29)
Real GDP (advance)	2.18* (2.50)	1.77* (2.06)
Initial Jobless Claims	-1.10** (-3.72)	-0.49* (-2.03)
NAPM/ISM Manufacturing	2.29** (2.66)	1.48* (2.56)
New Home Sales	0.62 (1.59)	1.44** (3.50)
Nonfarm Payrolls	4.54** (7.47)	0.54 (0.84)
Monetary Policy	0.24* (2.07)	-0.12 (-1.42)
# Observations	787	787
R^2	.14	.04
Joint test p -value	.0000**	.0000**

Notes: Sample: Jan 1998–Dec 2005 at daily frequency on the dates of macroeconomic and monetary policy announcements. Heteroskedasticity-consistent t -statistics reported in parentheses. *Significant at 5%; **Significant at 1%. Regressions also include a constant, a Y2K dummy that takes on the value 1 on the first business day of 2000, and a year-end dummy that takes on the value 1 on the first business day of any year (coefficients not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal and real rates. Joint test p -value is for the hypothesis that all seven coefficients (other than the constant and dummy variables) are zero. See text for details.

monetary policy surprises, which we leave in basis points, so that those coefficients represent a basis-point per basis-point response.²¹

4.1. The Impact of News on U.S. Short-Term Treasury Rates

The first column of Table 1 reports the responsiveness of the spot one-year U.S. Treasury rate to our macroeconomic and monetary policy announcements as a benchmark for the far-ahead forward inflation compensation results. Not surprisingly, we find that this short-term interest rate responds to these announcements with an overwhelming degree of statistical significance—the p -value for the joint hypothesis that all of the coefficients are equal to zero, excepting the constant and dummy variables, is below 10^{-15} . Moreover, the responses we estimate are all

21. Each regression also includes a constant, a “Y2K” dummy that takes on the value 1 on the first business day of 2000, and a year-end dummy that takes on the value 1 on the first business day of any year. These coefficients are not reported to save space and because we generally found them to be unimportant in our regressions.

consistent with what one would expect from a Taylor-type reaction function for monetary policy: Upward surprises in inflation, output, or employment lead to increases in short-term interest rates, and upward surprises in initial jobless claims (a countercyclical economic indicator) causes short-term interest rates to fall.

Although the magnitudes of the response coefficients in Table 1 might seem small at first glance—a two-standard-deviation surprise leads on average to a 3-basis-point change in the 1-year rate—they are in fact not surprising given the relatively high noise-to-signal ratio of the monthly data releases for the true underlying level of economic activity and rate of inflation. Similarly, the regression R^2 is only about 14%, implying that even on those 787 days when we know the major economic news that day, the regression explains only one-seventh of the variation in short-term rates due to the complexities of the announcement—our surprise data is only for the headline component of the release, whereas the full release is often much richer²²—and other factors influencing Treasury yields. Nevertheless, the extraordinary statistical significance of many of the individual coefficients and the regression as a whole imply that the economic releases in Table 1 do contain information that is extremely relevant for the behavior of short-term interest rates.

A final point worth noting in the short-rate regression in Table 1 is that monetary policy surprises lead to about a 1-for-4 response of the one-year yield to the federal funds rate. This is consistent with the view that a surprise change in the funds rate is generally not a complete surprise to markets, but rather a bringing forward or pushing back of policy changes that were largely expected to occur within the next year, anyway.²³

4.2. The Impact of News on U.S. Far-Forward Inflation Compensation

The second column of Table 1 addresses the central question of the paper: Does far-ahead forward inflation compensation in the U.S. respond systematically to economic news? If 10 years is a sufficient length of time for U.S. inflation to return essentially to steady state following an economic shock, and if long-term inflation expectations are firmly anchored in the U.S., then we would expect to see no systematic response of far-ahead forward inflation compensation to economic news. As is apparent in the second column of Table 1, this is not the case: Ten-year-ahead forward inflation compensation responds significantly—and often very highly so—to five of the seven macroeconomic announcements in

22. For example, the CPI release includes not just the top-line inflation numbers, but also a detailed breakdown of inflation by product category. Markets may respond differently to a given headline number depending on the underlying detail of the release and whether that detail suggests the news in the release is transitory or more permanent. Our professional forecast data covers only the top-line number. The situation is very similar for GDP and indeed all of the other macroeconomic statistics we consider.

23. Gürkaynak (2005) discusses this point in more detail.

the table, and the joint hypothesis that all of the coefficients in the regression are zero is rejected with a p -value below one in ten million.²⁴ Moreover, the signs and magnitudes of these coefficients are not random, but rather closely resemble those from the first column—that is, positive surprises to output or inflation cause far-ahead forward inflation compensation to rise in line with short-term rates. This is precisely the result we would expect if financial markets expected some degree of (or some chance of) pass-through from short-term inflation to the long-term inflation outlook.

The one exception to this empirical pattern is monetary policy announcements, for which the estimated effect on far-ahead forward inflation compensation is opposite the effect on the spot 1-year rate—that is, a surprise monetary policy tightening causes far-ahead forward inflation compensation to fall. Although this effect is not statistically significant in Table 1, Gürkaynak, Sack, and Swanson (2005) show that this same effect is statistically significant for far-ahead forward nominal interest rates over sample periods that extend back to 1990 or 1994. Again, this pattern is exactly what we would expect if financial markets expected some degree of (or some chance of) pass-through from short-term inflation to the long-term inflation outlook.²⁵

As was the case in the first column, the regression R^2 and magnitudes of the coefficients in the second column of Table 1 might seem small at first glance. However, the R^2 in the second column is about one-third the size of that for the one-year Treasury rate in the first column, suggesting a large degree of explanatory power for an interest rate which, under the null, should be a constant or statistical white noise. Moreover, the sensitivity of inflation compensation to economic news in the second column is almost as large as, and has the same sign as, the sensitivity of the short-term interest rate to these announcements. Because we know that short-term interest rates respond importantly to news about output and inflation, the sensitivity of far-ahead forward inflation compensation in the second column should also be regarded as being economically as well as statistically significant. Finally, although the effect of any single monthly announcement is only a few basis points, the effects of these announcements cumulate across releases and over time. Thus, the few basis points per announcement that we estimate often add up, over the course of just a few months, to large and significant changes in long-term interest rates and inflation compensation.

24. In the working version of this paper (Gürkaynak, Levin, and Swanson 2006), we also reported results for far-ahead forward nominal and real rates separately, but we do not report those here in the interests of space. By and large, far-ahead forward real rates appear unresponsive to data surprises in our sample. The signs of coefficients are mixed and there are very few significant coefficients. Beechey and Wright (2008) carry out a detailed study of the response of real rates.

25. Gürkaynak, Sack, and Swanson (2005) present a simple New Keynesian model which has the feature that long-term inflation expectations, rather than being perfectly anchored, exhibit some degree of loading on the recent history of inflation, and show that this model is consistent with all of the empirical findings in Table 1.

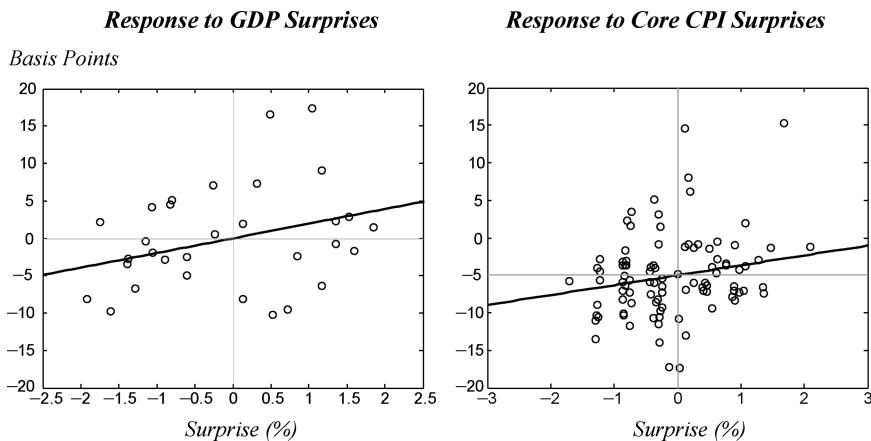


FIGURE 4. Daily changes in U.S. far-ahead forward inflation compensation. The left panel denotes quarterly observations of the percentage point surprise in the advance release of U.S. GDP (normalized by the standard deviation of these surprises) and the corresponding 1-day change in the 9-year-ahead 1-year forward rate of inflation compensation (in basis points); the right panel provides similar information for surprises in the monthly release of the U.S. consumer price index excluding food and energy. In each panel, the solid line indicates the least-squares regression line.

4.3. Sensitivity Analysis

Before drawing definitive conclusions from these regression results, some sensitivity analysis is certainly merited. We have performed a battery of outlier tests, which confirm that neither the magnitude of the estimated coefficients nor their statistical significance is sensitive to the exclusion of any single observation or pair of observations. The robustness of the results is also evident from the scatter plots in Figure 4. Each point in the left panel denotes the surprise in the advance release of GDP (horizontal axis) plotted against the corresponding one-day change in far-ahead forward inflation compensation (vertical axis), and the right panel provides similar information for core CPI surprises; in both cases, the systematic response of far-ahead forward inflation compensation is readily apparent.

We also consider whether the impact of economic news on far-ahead forward inflation compensation might be purely transitory, as one might expect if these systematic effects mainly reflected fluctuations in market liquidity or various technical factors. The first column of Table 2 repeats the regression results from the previous table (that is, the same-day response of inflation compensation to macroeconomic and monetary policy surprises), and the second and third columns report parallel results where the dependent variable is either the 2-day change or the 3-day change in far-ahead forward inflation compensation.

With the exception of surprises in the NAPM survey, these results generally indicate that these surprises have persistent effects on far-ahead forward inflation

TABLE 2. Multiday responses of U.S. long-run forward inflation compensation to economic news (1998–2005).

	Same-Day Response	Response After One Day	Response After Two Days
Core Consumer Price Index	1.51* (2.29)	2.06* (2.21)	1.44 (1.51)
Real GDP (advance)	1.77* (2.06)	2.29* (2.16)	2.71 (1.88)
Initial Jobless Claims	-0.49* (-2.03)	-0.54 (-1.36)	-0.75* (-1.97)
NAPM/ISM Manufacturing	1.48* (2.56)	0.57 (0.71)	0.40 (0.56)
New Home Sales	1.44** (3.50)	1.38* (2.26)	2.18** (3.16)
Nonfarm Payrolls	0.54 (0.83)	1.44 (1.42)	1.38 (1.41)
Monetary Policy	-0.12 (-1.42)	-0.08 (-0.75)	-0.06 (-0.41)
# Observations	787	971	967
R^2	.04	.02	.03
Joint test p -value	.0000**	.02*	.01**

Notes: Sample: Jan 1998–Dec 2005 at daily frequency on the dates of macroeconomic and monetary policy announcements. Heteroskedasticity-consistent t -statistics reported in parentheses. *Significant at 5%; **Significant at 1%; Regressions also include a constant, a Y2K dummy that takes on the value 1 on the first business day of 2000, and a year-end dummy that takes on the value 1 on the first business day of any year (coefficients not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal and real rates. Joint test p -value is for the hypothesis that all seven coefficients (other than the constant and dummy variables) are zero. See text for details.

compensation, consistent with the view that this news has a systematic influence on long-run inflation expectations and inflation risks. For the core CPI surprises, the magnitude of the regression coefficient is similar in all three columns of Table 2, confirming that the initial impact on far-ahead forward inflation compensation is not reversed over the next several days. For several other explanatory variables (namely, surprises in advance GDP, initial jobless claims, new home sales, and nonfarm payrolls), the estimated impact on far-ahead forward inflation compensation even grows over the course of 2 or 3 days; these patterns could indicate that the same-day effects of these surprises tend to be dampened by liquidity effects, or alternatively could reflect the extent to which some economic news receives further attention from market commentators and then induces further reverberations on inflation compensation.

5. The Sensitivity of UK Inflation Compensation to Economic News

Given the previous evidence that U.S. far-ahead forward inflation compensation has been more sensitive to economic news than one would expect if inflation expectations were perfectly anchored, we now investigate the extent to which

similar relationships are apparent in UK data. To shed further light on the role of the monetary policy regime, we first consider the sample period prior to mid 1997 and then turn to the period over which the Bank of England has had operational independence from the Government.

5.1. The Period Prior to Central Bank Independence

Although the United Kingdom officially adopted an inflation target in October 1992, the interest rate policy of the Bank of England continued to be set by the Chancellor of the Exchequer, who was a member of Parliament and of the Prime Minister's Cabinet. The lack of operational independence of the Bank of England arguably led to a diminished level of credibility, and survey data as well as bond yields indicate that long-term inflation expectations remained substantially higher than the official inflation target of 2.5%.²⁶

Table 3 reports regression results for UK data over the sample period from February 1993 to April 1997.²⁷ The format of the table is the same as Table 1, and indeed, the results here are quite similar to those for the United States. In particular, for this period, UK far-ahead forward inflation compensation appears to be very sensitive to economic news: Four of the seven coefficients exhibit a high degree of statistical significance, and the p -value indicates an overwhelming rejection of the joint hypothesis that these announcements have no systematic impact on the dependent variable. As in the U.S., these coefficients are very similar in magnitude to those for short-term rates, implying that the sensitivity is economically as well as statistically significant. Indeed, UK far-ahead forward rates during this period are even more sensitive to economic news, as measured by the regression R^2 , both in absolute terms and relative to short-term interest rates.

Interestingly, UK far-ahead forward inflation compensation responded inversely to monetary policy surprises over this period, to an extent that is even greater than was the case for the United States; that is, the UK estimates indicate that an unexpected easing or tightening of the stance of monetary policy would tend to have an even greater impact on far-ahead forward inflation compensation. This brings us to our final observation, which is that all of the significant coefficients in Table 3, including those on monetary policy announcements, are consistent with the view that during the period preceding the operational independence of the Bank of England, UK financial markets expected that near-term economic and monetary policy surprises would have substantial effects on the distribution of inflation outcomes at very long horizons.

26. See Section 6.1 herein and Figure 1.

27. Recall that the MMS data for the UK begin in February 1993. Moreover, there is a change in UK exchange rate and monetary policy regime in September 1992 which also suggests beginning the sample in January 1993.

TABLE 3. UK forward rate responses to economic news, pre-Bank of England independence (1993–April 1997).

	1-year Nominal Rate	1-year Forward Inflation Compensation ending in 10 yrs
Average Earnings	3.23** (3.33)	0.15 (0.20)
Real GDP (preliminary)	1.75 (1.68)	1.80* (2.02)
Manufacturing Production	0.76 (0.88)	0.33 (0.29)
Producer Price Index	2.13** (3.12)	2.22* (2.61)
Core Retail Price Index	2.39** (3.19)	2.60** (3.08)
Retail Sales	2.17** (2.98)	−0.19 (−0.24)
Monetary Policy	0.67** (5.73)	−0.60** (−5.99)
# Observations	237	237
R^2	.35	.21
Joint test p -value	.0000**	.0000**

Notes: Sample is Feb 1993–Apr 1997 at daily frequency on the dates of macroeconomic and monetary policy announcements. Heteroskedasticity-consistent t -statistics reported in parentheses. *Significant at 5%; **Significant at 1%. Regressions also include a constant and a year-end dummy that takes on the value 1 on the first business day of any year (coefficients not reported). Macroeconomic data release surprises are normalized by their full-sample standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal and real rates. Joint test p -value is for the hypothesis that all seven coefficients (other than the constant and dummy variables) are zero. See text for details.

5.2. The Period Following Central Bank Independence

On 6 May 1997, Chancellor of the Exchequer Gordon Brown announced that the Bank of England would be granted independence to set its own interest rate policy, and this motion was passed into law by Parliament on 23 April 1998, with an effective date of 1 June 1998. Thus, using a sample from July 1998 to December 2005, we now consider whether UK far-ahead forward inflation compensation continued to remain sensitive to economic news even after the Bank of England gained operational independence.

Indeed, as shown in Table 4, the effects of news are strikingly different for the post-independence sample: Although short-term interest rates in the first column continue to respond to economic news in very much the same way as in the earlier period, far-ahead forward inflation compensation now shows essentially no sensitivity to economic news. The series of retail sales surprises is the only explanatory variable with a statistically significant impact, and this variable has a negative coefficient that is inconsistent with the notion that near-term inflationary effects might pass through to the longer-term inflation outlook. Moreover, the joint hypothesis of zero coefficients on all explanatory variables cannot be rejected at

TABLE 4. UK forward rate responses to economic news, post-Bank of England independence (July 1998–2005).

	1-year Nominal Rate	1-year Forward Inflation Compensation ending in 10 yrs
Average Earnings	1.81** (4.12)	−0.26 (−0.94)
Real GDP (preliminary)	2.04** (4.02)	−0.49 (−0.54)
Manufacturing Production	1.26** (3.09)	−0.04 (−0.09)
Producer Price Index	0.21 (0.55)	−0.22 (−0.63)
Core Retail Price Index	2.60** (4.83)	−0.76 (−1.95)
Retail Sales	1.58** (3.92)	− 1.18** (−2.75)
Monetary Policy	0.72** (5.96)	−0.13 (−1.01)
# Observations	480	480
R^2	.24	.03
Joint test p -value	.0000**	.051

Notes: Sample: July 1998–Dec 2005 at daily frequency on the dates of macroeconomic and monetary policy announcements. Heteroskedasticity-consistent t -statistics reported in parentheses. *Significant at 5%; **Significant at 1%. Regressions also include a constant, a Y2K dummy that takes on the value 1 on the first business day of 2000, and a year-end dummy that takes on the value 1 on the first business day of any year (coefficients not reported). Macroeconomic data release surprises are normalized by their full-sample standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal and real rates. Joint test p -value is for the hypothesis that all seven coefficients (other than the constant and dummy variables) are zero. See text for details.

standard significance levels, and the regression R^2 is small, both in absolute terms and relative to the explainable variation in short-term interest rates. Thus, a known and credible inflation target seems to have anchored the perceived distribution of long-run inflation outcomes in the UK.

5.3. Sensitivity Analysis

As for the U.S. analysis, we have performed a battery of outlier tests to confirm that the UK results are not sensitive to the exclusion of any single observation or pair of observations. The robustness of these results is also evident from the scatter plots in Figure 5, where the left column of panels provides information about the pre-independence sample (February 1993 to April 1997), and the right column of panels gives parallel information for the post-independence sample (July 1998 to December 2005). Each scatter plot depicts the 1-day response of far-ahead forward inflation compensation to surprises in the advance release of real GDP (A), surprises in the core consumer price index (B), and surprises in monetary policy announcements (C).

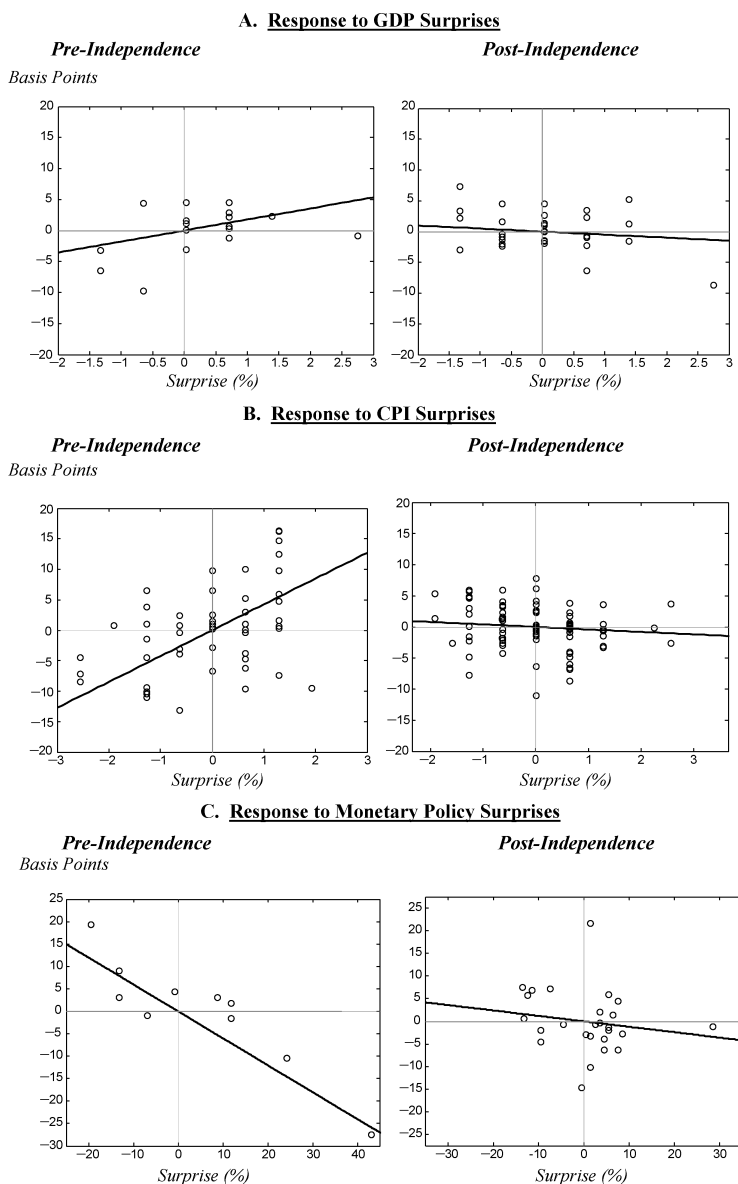


FIGURE 5. Daily changes in UK far-ahead forward inflation compensation. Each panel depicts the 1-day change in the UK 9-year-ahead 1-year forward rate of inflation compensation (in basis points) in response to a percentage point surprise in the advance release of UK GDP (A), the consumer price index (B), and monetary policy announcements (C), where each surprise has been normalized by the standard deviation of that series of surprises. For each panel, the left panel depicts data for the pre-independence sample period (February 1994 to May 1997), and the right panel depicts data for the post-independence sample period (July 1998 to December 2005). In each panel, the solid line indicates the least-squares regression line.

The contrast between the two sample periods is readily apparent: The systematic influence of economic and monetary policy surprises during the pre-independence period is completely absent from the post-independence data. Moreover, one specific outlier—the huge positive monetary policy surprise in the lower-right panel—is particularly noteworthy. On that day, 12 September 1994, Chancellor of the Exchequer Kenneth Clarke

became the first chancellor in living memory to take the unpopular step of raising interest rates not in response to soaring prices or a sterling crisis, but as a prudent move against future inflation... . Financial markets have hitherto been sceptical of the government's ability to meet its inflation target... . The chancellor's display of mettle strengthened his government's credibility and, as a result, caused long-term interest rates to fall. (*The Economist*, 1994)

Several aspects of the narrative in *The Economist* are consistent with the view that UK long-term inflation expectations were not very well anchored at that time. First, this datapoint represents a genuine surprise, not just an anomaly in the data, and hence bolsters the strong statistical significance of the coefficient on monetary policy announcements in that regression. Second, despite the existence of an official inflation target prior to Bank of England independence, the *Economist* story emphasizes that financial markets were skeptical about the Chancellor's commitment to the inflation target. Finally, the article directly attributes that day's movement in UK long-term interest rates as a response to the surprise in monetary policy, and, in particular, the extent to which this surprise influenced investors' perceptions of the long-term inflation outlook—precisely the explanation that seems consistent with all of our findings.²⁸

6. Additional Evidence

All of these results are consistent with the hypothesis that financial market perceptions of the distribution of long-run inflation outcomes in the U.S. and pre-1997 UK were not well anchored and responded systematically to economic news. Moreover, the model in Gürkaynak, Sack, and Swanson (2005) shows that all of these empirical results are consistent with financial markets expecting some degree of pass-through (or some chance of pass-through) from short-term inflation to the long-term inflation outlook. In the U.S., the Federal Reserve has no specific target for steady-state inflation, only a mandate for “price stability,” which the

28. *The Economist's* analysis of the Bank of England's move, rather than being idiosyncratic, was echoed throughout the British press at the time. For example, *The Financial Times* reported the day after the move that: “Mr. Kenneth Clarke, the chancellor, boosted his credibility,” that “the Bank of England's reputation was also enhanced,” and that “the clear message is that the Bank of England has much more independence in setting monetary policy than at any time in its history” (*The Financial Times*, 1994).

Fed has interpreted broadly. In the pre-1997 UK, although there was an official numerical inflation target, that target appears to have not been credible due to lack of central bank independence. By contrast, in the UK since independence in 1998, far-ahead forward inflation compensation has been quite stable and insensitive to economic news, consistent with the view that a credible inflation target helps to anchor private sector views about the distribution of long-run inflation outcomes.

If this hypothesis is correct, then we might expect to see the effects of a credible inflation target manifesting itself in measures of inflation expectations other than bond yields and in inflation targeting countries other than the UK. In this section, we consider such additional supporting evidence. In particular, we show that lower-frequency, survey-based measures of inflation expectations in the U.S. and UK corroborate our findings above, and that far-ahead forward inflation compensation in Sweden, another inflation targeting country with a relatively long history of inflation-indexed bonds, also appears well-anchored. Finally, we discuss the robustness of our results to possible time-variation in term premia.

6.1. Disagreement among Professional Forecasters

Cross-country comparisons using survey data are inevitably fraught with difficulties, due to differences in the sampling methodology and other idiosyncrasies. Nevertheless, it is useful to gauge the degree of consensus or disagreement among professional forecasters regarding the longer-run inflation outlook for the United Kingdom and the United States.

For more than a decade, the Federal Reserve Bank of Philadelphia has conducted a quarterly Survey of Professional Forecasters (SPF) that includes a projection of the 10-year-average inflation rate for the U.S., and measures of dispersion across forecasters can be constructed using the entire set of individual projections. Since 1997, the Bank of England's Inflation Report has also included a summary of its latest survey of external forecasters (SEF). Each Bank of England survey elicited inflation projections based on the price index that was referenced in the Bank's inflation target; that is, the RPIX in surveys through the last quarter of 2003, and the CPI in surveys since 2004. Moreover, these projections were provided for the annualized one-quarter inflation rate at forecast horizons up to nine quarters ahead—the horizon at which the Bank generally intends that inflation will be stabilized at the target value. Although individual survey responses are not reported, the cross-sectional dispersion in forecasters' inflation projections is evident from the histogram published in each Inflation Report.

Absent any other considerations, one might anticipate that a comparison of these two surveys would reveal greater dispersion in nine-quarter-ahead UK inflation projections than for 10-year-average U.S. inflation projections. Indeed, even with a transparent and credible inflation target, some shocks to the UK economy might well have inflationary consequences lasting longer than two years;

hence, substantial uncertainty—and a corresponding degree of dispersion across forecasters—would be evident at a nine-quarter forecast horizon. And if U.S. long-run inflation expectations were firmly anchored, one might anticipate that the current state of the economy would have only modest implications for the average inflation rate over the subsequent decade, implying that professional forecasters' projections at that horizon would be concentrated in a fairly narrow range.

Despite these limitations, the survey evidence confirms that inflation expectations of professional forecasters have been anchored quite firmly in the United Kingdom. As depicted in the left panel of Figure 6, about two-thirds of the participants in the SEF in 2001:Q4 were projecting that UK inflation nine quarters later would fall within 0.1% of the Bank of England's inflation target of 2.5%, and nearly all of the participants expected that inflation would fall within 0.4% of the Bank's target.

The bottom panel of this figure suggests that the Bank of England was reasonably successful in communicating about the switch in its inflation measure in late 2003; that is, by 2004:Q1, the SEF respondents' nine-quarter-ahead inflation projections for the HICP were concentrated at the new inflation target of 2%, with relatively little change in the cross-sectional distribution.

The survey evidence also highlights the extent to which long-run inflation expectations have not been completely anchored in the United States. Only one-third of the respondents in the 2001:Q4 SPF were projecting the 10-year-average U.S. inflation rate at roughly the modal value of 2.5%, and the projections of other respondents were distributed almost uniformly over an interval from 1.5% to 3.2%. Moreover, as of 2004:Q1, the distribution of SPF inflation projections was even more dispersed than in late 2001, showing greater heterogeneity of expectations of inflation at long horizons.²⁹

6.2. Swedish Bond Yield Data

In Table 5, we report results for regression equation (2) applied to Sweden. Like the UK, Sweden has been an official inflation targeter throughout much of the 1990s: After abandoning its currency peg in late 1992, the Riksbank (the Swedish central bank) announced in January 1993 that it would adopt an inflation targeting framework with an official target of 2% that would become effective beginning in January 1995 (thus, there is some ambiguity about exactly what date should be regarded as the beginning of the inflation targeting regime). Our

29. Note that dispersion of mean beliefs (heterogeneity) and mean dispersion of beliefs (uncertainty) are two separate objects. Credible inflation targets are supposed to affect both distributions. The distribution of possible inflation expectations in the far future should be stable and agents should have similar beliefs, centered on the inflation target. The evidence presented here shows that the dispersion of beliefs across agents corroborates our findings based on the average perceived distribution of possible inflation outcomes reflected in far-ahead forward inflation compensation.

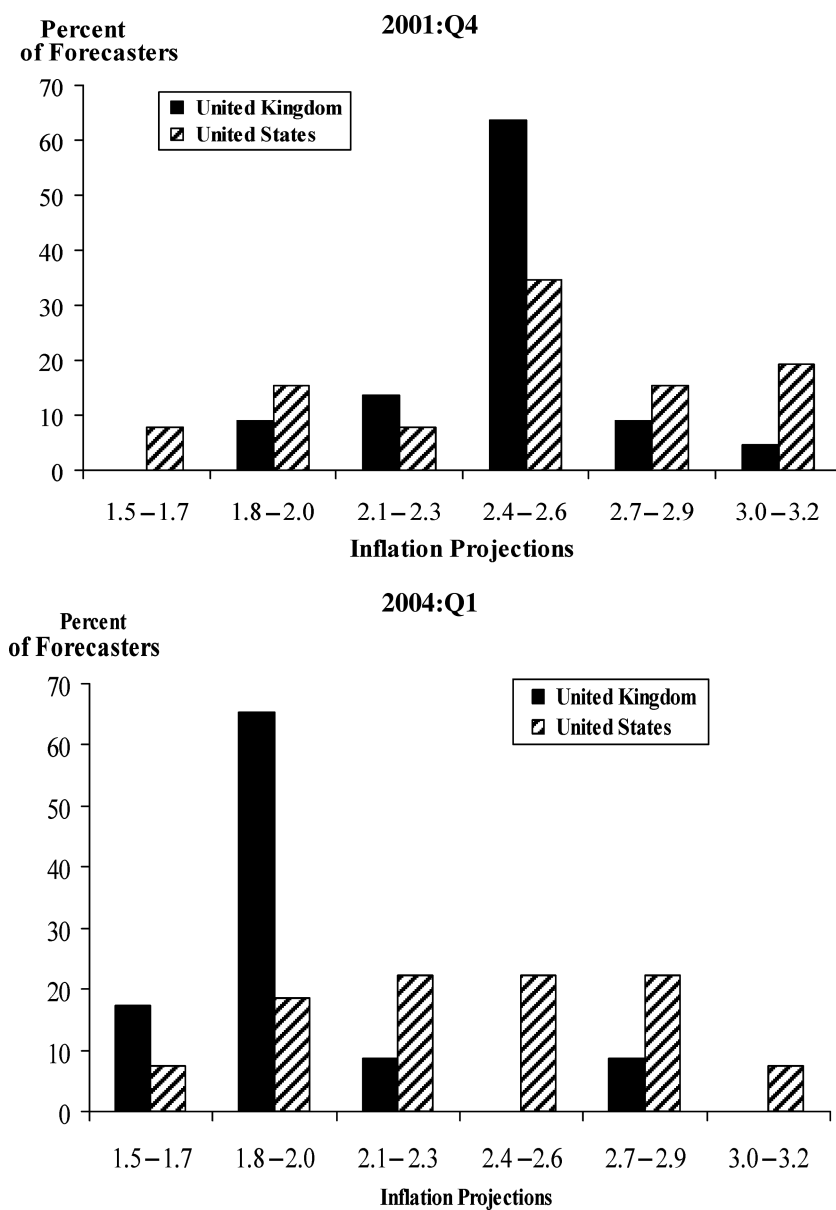


FIGURE 6. Disagreement in medium-to-long-run inflation projections for the United Kingdom and the United States. This figure depicts the cross-sectional dispersion in professional forecasters' medium-to-long-run inflation projections in 2001:Q4 (top) and in 2004:Q1 (bottom). The solid bars represent the histogram of nine-quarter-ahead projections for the UK RPIX in 2001:Q4 and for the UK of HICP in 2004:Q1, taken from the Bank of England's quarterly survey of external forecasters. The hatched bars represent the histogram of projections in each period for the 10-year-average U.S. CPI inflation rate, taken from the Federal Reserve Bank of Philadelphia's Survey of Professional Forecasters. In each case, all of the professional forecasters' projections fell within the range of 1.5-3.2%.

TABLE 5. Swedish forward rate responses to economic news (1996–2005).

	1-year Nominal Rate	1-year Forward Inflation Compensation ending in 10 yrs
Consumer Price Index	1.94* (2.55)	0.85 (1.13)
Core Consumer Price Index	2.72** (4.26)	−0.33 (−0.37)
Real GDP (preliminary)	0.79 (1.17)	0.29 (0.45)
Industrial Production	−0.14 (−0.24)	−0.67 (−1.55)
Producer Price Index	0.63 (0.83)	−0.24 (−0.76)
	−0.49	0.65
Retail Sales	(−0.72)	(1.21)
	−0.26	−0.04
Unemployment	(−0.67)	(−0.11)
Monetary Policy	0.72** (3.62)	0.23 (1.48)
# Observations	514	514
R^2	.07	.01
Joint test p -value	.0000**	.420

Notes: Sample: May 1996–Dec 2005 at daily frequency on the dates of macroeconomic and monetary policy announcements. Heteroskedasticity-consistent t -statistics reported in parentheses. *Significant at 5%; **Significant at 1%. Regressions also include a constant, a Y2K dummy that takes on the value 1 on the first business day of 2000, and a year-end dummy that takes on the value 1 on the first business day of any year (coefficients not reported). Macroeconomic data release surprises are normalized by their standard deviations, so that coefficients represent a basis point per standard deviation response. Monetary policy surprises are in basis points, so that those coefficients represent a basis point per basis point response. Inflation compensation is the difference between nominal and real rates. Joint test p -value is for hypothesis that all eight coefficients (other than the constant and dummy variables) are zero. See text for details.

inflation-indexed bond yield data for Sweden begin in May 1996, so we begin our analysis of Sweden with that date, which has the added advantage of giving the Riksbank a few years to gain operational experience within the new floating exchange rate regime and to establish some degree of credibility with respect to the inflation target (see, e.g., Berg and Grottheim 1997).

As can be seen in Table 5, the results for Sweden are very similar to those for the United Kingdom after the Bank of England gained independence, and are strikingly different from those for the United States or for the pre-independence sample period for the United Kingdom. Although the regression R^2 for the short rate in Sweden is lower than for the U.S. or UK (perhaps because our data on major Swedish economic announcements is less comprehensive than our data for the U.S. and UK), Swedish short-term interest rates nonetheless respond with a high degree of statistical significance to three major macroeconomic and monetary policy announcements, and the data overwhelmingly reject the hypothesis that the one-year rate in Sweden is unrelated to these announcements. Yet far-ahead forward nominal interest rates and inflation compensation in Sweden show no

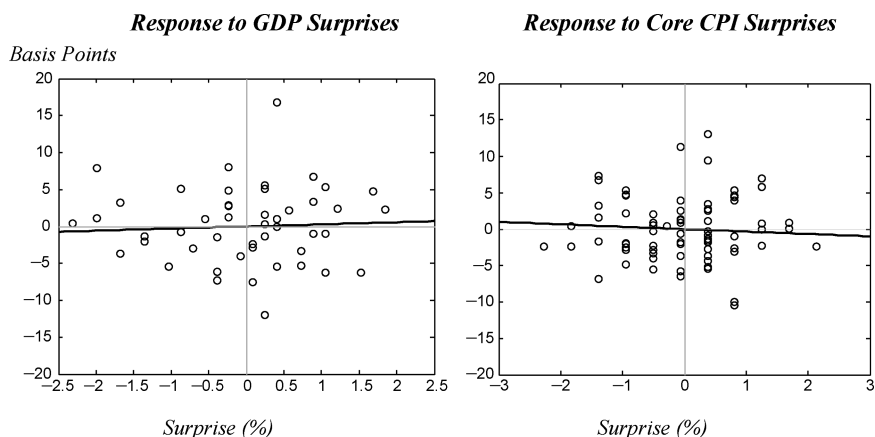


FIGURE 7. Daily changes in Swedish far-ahead forward inflation compensation. The left panel denotes quarterly observations of the percentage point surprise in the advance release of Swedish GDP (normalized by the standard deviation of these surprises) and the corresponding 1-day change in the Swedish 9-year-ahead 1-year forward rate of inflation compensation (in basis points); the right panel provides similar information for surprises in the monthly release of the Swedish core consumer price index. In each panel, the solid line indicates the least-squares regression line.

statistically significant relationship to any of these releases, and the joint hypothesis that the coefficients on all of these releases are zero is not rejected.

The Swedish results are shown graphically in Figure 7. Just as in the more recent data sample for the United Kingdom, there is no systematic relationship between economic news and far-ahead forward inflation compensation, providing further support for the view that an explicit long-run inflation target is helpful in anchoring long-run inflation expectations.

6.3. The Role of Risk Premia

In interpreting and discussing our results to this point, we have emphasized financial market perceptions of the distribution of long-term inflation outcomes. An alternative explanation for our bond yield regression results is one that relies not on changes in the physical or objective distribution of long-term inflation outcomes, but rather on the prices that financial markets place on those risks. In this section, we turn to the possible role of time-varying risk premia in explaining our bond yield regression findings. Note, however, that our survey-based measures of longer-term inflation expectations in Section 5.1 are in principle completely free of risk premia, providing an additional check on our results and their interpretation.

It should be emphasized at the outset that none of our regression results and their interpretation require the expectations hypothesis (EH) of the term structure

to hold. According to the EH, long-term bond yields equal the expected return to rolling over a series of short-term bonds over the same horizon, plus a possibly nonzero term premium that is constant over time. Although some authors have found some support for the EH in the data (e.g., Bekaert, Hodrick, and Marshall 2001), a number of prominent studies (Fama and Bliss 1987; Campbell and Shiller, 1991) have documented strong violations of the EH over a wide variety of samples and securities, suggesting that the risk, term, liquidity, and/or other premia (often collectively referred to as “risk premia”) embedded in long-term bond yields may in fact vary substantially over time.

However, even if the EH is violated, our results and their interpretation are essentially unaffected so long as those risk premia vary primarily at lower frequencies—monthly, annual, or business-cycle frequencies, say. In that case, the change in bond yields on any given day effectively differences out the risk premium on that day and leaves changes in market expectations as the primary driver of the 1-day change in yields. Although there is no reason *a priori* to think that risk premia should vary only at lower frequencies, the predictors of excess returns on bonds found by these studies in fact do have this feature, in particular, that risk premia vary primarily at business-cycle frequencies (Cochrane and Piazzesi 2005).

Most importantly, however, in order for changes in risk premia to explain our findings, one would have to explain why these premia would vary systematically in precisely the way that we estimate. For example, it would be a challenge to explain why risk premia might increase in response to positive news about output and employment and decrease in response to negative news about these variables, when a consumption-CAPM model and the results of Cochrane and Piazzesi (2005) and Piazzesi and Swanson (2008) would predict just the opposite. Moreover, it seems difficult to explain why risk premia might respond to economic news in the U.S. and in the pre-1997 UK, but not in Sweden or in the post-independence UK. The Swedish bond market in particular is much smaller than the U.S. market, so one might think that liquidity or other risk premia would, if anything, be even more of an issue in that country than in the U.S.

None of this is meant to imply that risk premia have been unimportant over our sample—indeed, one possible explanation for the volatility in the forward inflation compensation series in Figures 1 and 2 is precisely changes in risk premia over time. It is just that volatility in risk premia by itself is not sufficient to explain all of our results—one would have to explain why those risk premia move so systematically in response to news in just the way that a pass-through from short-term inflation to longer-term inflation would suggest.

We are sympathetic to the view that changes in the mean expected long-run inflation rate may not be responsible for our findings so much as changes in the skewness or other moments of that distribution, but this idea is in fact entirely consistent with our preferred interpretation—namely, that inflation targeting helps to

anchor market perceptions of the entire distribution of future long-run inflation outcomes.

7. Conclusions

Does inflation targeting help to anchor private sector perceptions of the future distribution of long-run inflation outcomes? We find much evidence that it does. In contrast to previous studies using quarterly or even semiannual data, we have presented evidence from thousands of daily observations of long-term bond yield responses to economic news in the U.S., UK, and Sweden that support this conclusion. Far-ahead forward inflation compensation in the U.S. and the pre-1997 UK is much more volatile and responds much more significantly to economic news than far-ahead forward inflation compensation in the post-1998 UK or Sweden. Longer-term inflation expectations of professional forecasters, taken from surveys in the U.S. and UK, further corroborate these findings.

Our results have potentially important implications for the U.S. Despite the generally superb performance of the U.S. economy and U.S. monetary policy in the 1990s and 2000s, we find that, with respect to long-term interest rates and inflation expectations, the gains realized in the UK and Sweden over this period have been even greater. In particular, the Federal Reserve's informal approach to a long-run inflation objective does not seem to have anchored the private sector's long-term inflation views to the same extent that we see in the UK and Sweden, both formal inflation targeters. This performance has been all the more remarkable in light of the greatly inferior inflation expectations in the UK and Sweden relative to the U.S. that existed in the early 1990s.

Although the sensitivity we estimate is only a few basis points per announcement, it may be economically important for two reasons. First, although the effect of any single monthly announcement is only a few basis points, the effects of these announcements must be cumulated across releases and over time—in other words, even though any single monthly data release is just one noisy indicator of the state of U.S. economy, the information content of those releases is larger when we consider them jointly and over time. Thus, the few basis points per announcement that we estimate often adds up, over the course of just a few months, to large and significant changes in long-term interest rates.³⁰ Second, the sensitivity of far-ahead forward inflation compensation to economic news that we estimate is almost as large as the sensitivity of short-term interest rates to these

30. More technically, the variance of a unit root process increases linearly over time. Monthly U.S. economic activity and inflation are close enough to unit root processes that the variance of the cumulative sum of monthly data releases increases essentially linearly in the near term. Thus the impact of these announcements on long-term interest rates will have a tendency to cumulate strongly in the near term with a variance that grows linearly with time in the near term.

announcements. Because we know that short-term interest rates should and do respond substantially to current output and inflation, the sensitivity of far-ahead forward inflation compensation that we estimate should also be regarded as being economically as well as statistically significant.

There are many interesting ways to follow up on our findings, but two stand out. The first is to study the episode of financial market stress and high commodity price—when it is over—using the framework of this paper. Central bank responses have been different across countries and it would be very interesting to find out whether these differences have been reflected in the behavior of forward inflation compensation. The second very interesting question to study is expected welfare gains for the U.S. from stabilizing long-term inflation expectations via an explicit inflation target.

Although we have not shown in this paper that there any advantages, either qualitatively or quantitatively, to the stabilization of long-term inflation expectations, existing macroeconomic and finance theory suggests that there should be several—for example, less persistent deviations of inflation from target in the near term due to firmer anchoring of expectations at the long end, and a greater ability of the central bank to control inflation in the short and medium run (Svensson and Woodford 2003; Woodford 2003; Orphanides and Williams 2005); less volatile long-term nominal interest rates and lower risk premia on nominal rates that would improve the efficiency of investment decisions (Ingersoll and Ross 1992); and a reduced chance of a 1970s-style “expectations trap” for inflation (Albanesi, Chari, and Christiano 2003) or an imperfect information-driven “inflation scare” (Orphanides and Williams 2005). To the extent that these benefits are important in practice as well as in principle, there are reasons to think that, with a more explicit inflation objective, U.S. monetary policy and economic performance could be improved even beyond the successes of the past 20 years.

Data Appendix

Data on U.S. macroeconomic statistical releases and forecasts were collected by Money Market Services up through July 2003, when that company merged with a larger financial institution. Subsequent to July 2003, the same survey was produced again by Action Economics. These data can be purchased from Haver Analytics as part of the “MMS” series of data at (<http://www.haver.com>).

For the UK, we also obtained MMS data for the UK from Haver Analytics. For the UK, many of the MMS series are reported both as month-on-month and year-on-year changes, so this presents an issue in terms of which version of each statistic to use in our analysis. If one version contained many more observations than the other, then we used the version that had more observations—in every

case, this turned out to be the year-on-year version (for some series, the month-on-month version was not collected or reported by MMS at all). When the number of observations was similar across the two versions, we used the year-on-year changes by default, because those were the versions that were more often available in general and those are the versions that are reported in the headlines of the British press. In any case, we have verified that whether we use the month-on-month or year-on-year changes for the statistical releases has essentially no impact on our results.

For Sweden, we obtained data on statistical releases and private sector forecasts from Bloomberg Financial Services. Bloomberg offers forecasts of a greater number of Swedish and Euro area statistics than Money Market Services that were more readily available to us. Bloomberg also offers these data for the U.S. and UK as well, although they do not go as far back as the MMS data (about 1996 for Bloomberg vs. 1985 for MMS-U.S. and 1993 for MMS-UK), but the two data sources agree very closely when they overlap. As in the UK, when there is a choice between the year-on-year and month-on-month versions of a statistical release, we favor the year-on-year version unless there are more data available for the month-on-month version. Also as in the UK, whether we use the month-on-month or year-on-year versions has very little effect on our results.

The exact statistics we use for all of these countries, including MMS and Bloomberg mnemonics, are reported in the following tables.

United States

Name	MMS/Haver Mnemonic
core Consumer Price Index	{L,M}111CPCM
real GDP (advance)	{L,M}111GPAA
Initial Jobless Claims	{L,M}111IC
NAPM/ISM Manufacturing	{L,M}111PMIF
New Home Sales	{L,M}111HNST
Nonfarm Payrolls	{L,M}111ED

United Kingdom

Name	MMS/Haver Mnemonic
Average Earnings	{L,M}112AEPY
real GDP (preliminary)	{L,M}112GPAY
Manufacturing Industrial Production	{L,M}112MFPY
Producer Price Index	{L,M}112PPIY
Retail Price Index excl Mortgage Interest	{L,M}112RPXY
Retail Sales	{L,M}112RSRY

Sweden

Name	Bloomberg Mnemonic
Consumer Price Index	swcpsyoy
core Consumer Price Index	swcpundy
real GDP (preliminary)	swgdpwyy
Industrial Production	swipnsyy
Producer Price Index	swppiyoy
Retail Sales	swrsiyoy
Unemployment	swue

Monetary Policy Surprises

For the U.S., we measure monetary policy surprises using federal funds futures, which provide high-quality, virtually continuous measures of market expectations for the federal funds rate. Gürkaynak, Sack, and Swanson (2007) show that, among the many possible financial market instruments that potentially reflect expectations of monetary policy, federal funds futures are the best predictor of future policy actions. The federal funds futures contract for a given month settles at the end of the month based on the average federal funds rate that was realized over the course of that month. Thus, daily changes in the current-month futures rate reflect revisions to the market's expectations for the federal funds rate over the remainder of the month. (Our results are essentially unchanged if we instead use the change in a 3-month interest rate, such as the 3-month Treasury bill rate, on the days of monetary policy announcements.) As explained in Kuttner (2001) and Gürkaynak, Sack, & Swanson (2007), the change in the current month's contract rate on the day of a Federal Open Market Committee (FOMC) announcement can be scaled up to account for the timing of the announcement within the month to provide a measure of the surprise component of the FOMC decision.³¹ We compute the surprise component associated with every FOMC meeting and intermeeting policy action by the FOMC over our sample.³²

For the United Kingdom, we do not have futures data for the policy rate of the Bank of England, so we measure monetary policy surprises using the change in the 3-month government bill rate (obtained from the Bank of England's Web site) on the days of Bank of England monetary policy announcements. The change in

31. In order to avoid very large scale factors, if the monetary policy announcement occurs in the last seven days of the month, we use the next-month contract rate instead of scaling up the current-month contract rate.

32. There is one exception in that we exclude the intermeeting 50-basis point easing on 17 September 2001 because financial markets were closed for several days prior to that action and because that easing was a response to a large exogenous shock to the U.S. economy, and we would have difficulty disentangling the effect of the monetary policy action from the effect of the shock itself on financial markets that day.

the 3-month rate on these days reflects changes in financial market expectations about the current and future course of monetary policy over the subsequent 3 months. Although this is not the same as the shorter horizon one would obtain from a very near-term futures contract, it is nonetheless an excellent measure of the change in the near-term monetary policy environment. When the 1-day change in the government bill rate isn't available (this is the case for many observations in the pre-1997 period), we use the 2-day change in the spot 3-month sterling London Interbank Offer Rate (LIBOR). (The LIBOR rate is quoted at around 11 a.m. London time and we do not always know at what time the monetary policy announcement was made to the public, so we must use a two-day window to be sure of bracketing the announcement.) Prior to May 1997, the only monetary policy announcements that we have are actual changes in the policy rate by the Bank of England, the dates of which we obtained from the Bank of England's Web site. After May 1997, there are well-defined announcement dates in the event of no change in policy rate as well. For comparability to the pre-1997 period, we continue to focus only on changes in the policy rate from 1998–2005, but our results are very similar if we use all monetary policy announcements (including those with no rate change) in the post-1998 period.

For Sweden, we also do not have futures data on the monetary policy instrument and use the change in the 3-month Swedish Government Bill rate on the days of Riksbank monetary policy announcements, which we obtained from the Swedish Riksbank's Web site.

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